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# LOGISTICS MANAGEMENT: OPPORTUNITIES IN THE CLOUD

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## ABSTRACT

The Internet provides an opportunity to facilitate business strategies and operations by enabling some logistics computing technologies to be outsourced and leveraged. Specifically, cloud computing provides numerous opportunities and value-added capabilities that logistics organizations require in order to remain competitive and be successful; however, there are conflicting viewpoints regarding cloud viability. The purpose of this study is to explore the perceived use of cloud computing and its functionality in logistics, to identify what types of cloud computing architectures, Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and cloud deployments (public, private or hybrid) are most utilized for logistics operations, and to determine the advantages and disadvantages logistics firms see in cloud computing. The model developed here is based on the Theory of Reasoned Action and explores logistics/IT managers' perceptions of cloud computing.

## Keywords

Cloud computing, theory of reasoned action, logistics, logistics information systems, infrastructure as a service, software as a service, platform as a service, public, private, hybrid

## INTRODUCTION

Cloud computing represents a shift from locally installed programs, servers and computers to the Internet deployment of software and computing capacity, helping reduce IT upfront and maintenance costs. Also, computer resources that can be easily turned on and off and scaled up or down depending on demand is another benefit of cloud computing. In 2010, small companies spent \$2.4 billion on cloud computing services, up from \$1.7 billion in 2009 in order to cut costs and improve efficiency during the recession (Martin, 2010). Cloud computing represents an operational necessity. For example, in a grocery store, cloud computing helped reduce stock out, improved inventory turnover and increased profits after it linked its suppliers via cloud ordering (Jones, 2011). Also, using the cloud for a project at a children's hospital in Seattle reduced project time delivery to six days from what would have taken several months to complete using in-house systems (Jones, 2011). According to a KPMG survey, one in ten businesses is running core information systems in the cloud (KPMG, 2011). Mainly driven by economic factors, enterprises adopt cloud services to reduce their total cost of ownership and to offer more flexibility, agility, collaboration and other technical services across firms in distant locations that cannot afford their own data centers (KPMG, 2011, Martin, 2010, McKendrick, 2011).

It is important to balance the cost saving, agility, disaster recovery, and efficiency against issues such as risk, compliance, tax and security (KPMG, 2011, Reuters, 2011). The biggest issue with cloud computing involves security. In a survey, 51% of small businesses affirm that security and privacy were the main reasons for not using cloud services (Martin, 2010). Another concern of cloud services is reliability, such as maintaining power and Internet connection during storms, hurricanes or other natural hazards (Watson, 2011). Security and reliability are issues of every computing environment with hackers accessing hard drives and servers, thieves stealing computer laptops and natural hazards affecting business operations (Martin, 2010). Although some suggest that cloud computing is here to stay (Han, 2010), the 2011 State of Cloud Survey (Symantec) found that organizations that have moved to the cloud haven't seen the benefits expected (Watson, 2011).

Cloud computing services for logistics and supply chain management are available for applications such as warehouse management systems (WMS), transportation management systems (TMS) and enterprise resource management (ERP) and provide consistent global platforms, shared real-time data, faster decision-making, improved customer service and greater automation and efficiencies. Jaguar Freight Services implemented Descartes global logistics technology (transportation manager) to deliver accurate real-time information without the cost, installation and maintenance of conventional TMS (Ginsburg, 2011). The air transportation industry cut costs by consolidating servers in regional data centers, and by being able to quickly adapt to industry changes - such as route expansions, disruptions or traffic spikes (Nguyen, 2011). Moreover, cloud computing allows third party logistics firms (3PLs) to acquire and pay only for the technology and functions they need, reducing IT personnel and infrastructure, savings that allow them to provide competitive prices and improved services

(Novak, 2011). For the supply chain area, eBuilder is a company that offers products for order fulfillment including: inbound, outbound, distribution, and after sales (reverse logistics). eBuilder also integrates all the stakeholders involved in the supply chain, provides visibility with information (track and trace), employs business intelligence strategic view to reduce costs, improves compliance and optimizes the supply chain (Juretic, 2011).

Evolving logistics network architectures require flexible IT systems that are easily inter-connectable, but also quick to change whenever necessary (Helo and Szekely, 2005). Cloud computing, on one hand, provides systems integration and many opportunities for some firms to differentiate themselves; on the other hand, security, reliability and performance issues hinder its advantages. The purpose of this study is three fold: first, to explore the perception of cloud computing among logistics firms. What advantages and disadvantages do logistics firms perceive from cloud computing? Second, the study explores the usage of logistics information systems in the cloud. What do logistics/IT managers perceive as suitable types of logistics information systems for the cloud? Third, the study also looks at the different cloud computing deployment (e.g., public, private, hybrid) preferences among logistics firms. What are the perceived preferred deployments of cloud services among logistics organizations? It is known that advances in information and communication technology enable new possibilities for managing the supply chains, especially if the advancement combines system integration with chain level view of the material flow (Helo and Szekely, 2005).

## LITERATURE REVIEW

### Cloud Computing Overview

According to the National Institute of Standards and Technology (NIST), cloud computing is defined as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell and Grace, 2011). Computing is being transformed to a model consisting of commoditized services, a “cloud” from which users access applications anywhere in the world on demand (Buyya, Yeo, Venugopal, Broberg and Brandic, 2009). According to Zhang, Q., Cheng, L. and Boutaba, R. (2010), the cloud is composed of four layers:

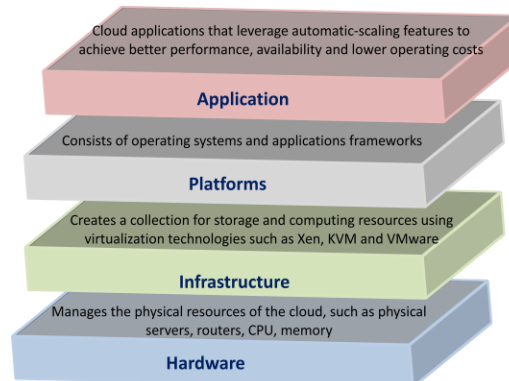


Figure 1. Four Layers of Cloud Computing, Adapted From Zhang et al. (2010)

Cloud computing users have access to three types of services: SaaS, PaaS, and IaaS (Weinhardt, Anandasivam, Blau, Borissov, Meinl, Michalk and Stöber, 2009). SaaS allows users to run existing on-demand online applications accessed over the Internet (e.g. Warehouse Management Systems, Transportation Management Systems, BIRetail, BISCIM, Salesforce.com, Rackspace and SAP Business by Design). PaaS allows users to create their own applications using supplier-specific tools and languages (e.g., OMSPlatform, eBuilder, Google App Engine, Microsoft Windows Azure and Force.com). IaaS allows users to run any applications of their own choice on cloud hardware (e.g. AmazonEC2, GoGrid and Flexiscale) (Mell and Grace, 2011, Zhang, Cheng and Boutaba, 2010).

Cloud computing applications can be deployed via public, private or hybrid clouds (Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, Lee, Patterson, Rabkin, Stoica and Zaharia, 2010, Marston, Li, Bandyopadhyay, Zhang and Ghalsasi, 2011, Mell and Grace, 2011, Zhang et al., 2010). The type of deployment depends on the company's desired level of security, reliability, performance and cost. In public clouds, the infrastructure and services are available for open use by the general public (Mell and Grace, 2011). In public clouds, firms are not required to invest in infrastructure, but firms lack control over data, network and security settings. Private clouds (e.g., internal data centers) are designed exclusively for a single organization with multiple consumers and are not available to the general public (Armbrust et al., 2010, Mell and Grace, 2011). Private clouds offer the highest degree of control over performance, reliability and security, but they do not provide up-front capital savings. In hybrid clouds, one part of the service infrastructure runs in private clouds, and another part runs in public clouds,

giving tighter control and security and also facilitating on-demand service expansion and reduction. (Mell and Grace, 2011, Zhang et al., 2010). Firms select different types of deployment depending on individual business needs.

Cloud computing offers different features that traditional service computing cannot provide. The cloud services are owned by multiple providers co-located in a single data center. The data centers are located globally and provide access to any device that has Internet connectivity (e.g., mobile phone, a PDA or a laptop). The computing resources are obtained and released on the fly according to the needs of the users. Firms are able to lower their operating costs, paying only for what they use, and passing the costs of computer maintenance and updates to the cloud providers (Zhang et al., 2010).

## CONCEPTUAL MODEL

Some logistics computing technologies (e.g., WMS, TMS, ERP) are outsourced and leveraged through the Internet facilitating business strategies and operations. Logistics firms considering adopting cloud computing services must find an alignment between their business strategy and the cloud service. For example, Cardinal Hosted Logistics has integrated software as a service solution through the industry and recently received the “TMWSuite 2011 Technology Award” (PRNewswire, 2011) for providing customers with flexible, integrated and customized services, such as transportation orders, time, real-delivery route monitors, warehouse and inventory management and integrated voice technology, among others (Cardinal, 2011). There are conflicting viewpoints regarding the cloud viability. The purpose of this study is to determine whether the logistics function would benefit from the use of cloud computing. Specifically, what advantages and disadvantages do logistics firms distinguish from cloud computing? The model based on the theory of reasoned action (Ajzen and Fishbein, 1975) explores logistics/IT managers’ perceptions of cloud computing.

This study replicates Benlian and Hess’ (2011) research on SaaS adoption and extends it to include PaaS and IaaS. 3PLs are not only renting cloud applications but also providing dedicated technology through cloud computing. Cloud computing provides numerous opportunities and value-added capabilities that logistics organizations require to remain competitive and be successful. This study intends to identify what types of cloud computing architectures, SaaS, PaaS, IaaS, are mostly utilized for logistics operations.

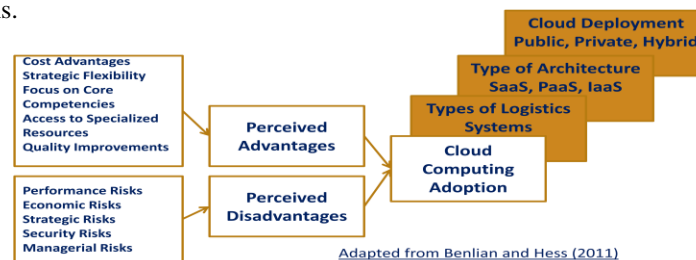


Figure 2. Conceptual Model

Moreover, this study aims to identify which logistics systems are more suitable for cloud computing. LIS technology (e.g. warehouse management systems (WMS), transportation management systems (TMS), collaborative planning forecasting and replenishment (CPFR), materials requirement planning (MRP) and enterprise resource planning (ERP)) enhances visibility, as well as integrates and coordinates supply chains (Holcomb, Ponomarov and Manrodt, 2011). A third-party logistics provider, RJW Transport, doubled its warehousing revenue after implementing a WMS in the cloud. The system gave access to more accurate, real-time information and expanded inventory visibility both internally and externally (RedPrairie, 2011). Unfortunately, not every company is able to make substantial initial investments or post-investments in technology such as EDI, ERP or WMS, among others (Srinivasan, Kekre and Mukhopadhyay, 1994). This research aims to identify the logistics information systems (LIS) that are perceived as more suitable for cloud benefits.

Finally, this study looks at what types of cloud computing deployment (public, private, and hybrid) are preferred or used by logistics firms. Logistics firms should consider all the hidden costs of implementing cloud computing (e.g., security, reliability, compliance) prior to moving to the cloud. Cloud computing may benefit small companies with limited capital expenditures by allowing them to operate and grow and providing them with capabilities and resources that would otherwise be unattainable. Every cloud model comes with different sets of security and cost-related implications (Microsoft, 2011). This research identifies which cloud deployment model is preferred by most logistics organizations. The logistics/IT managers’ perceived advantages and disadvantages of cloud computing will positively and negatively influence the adoption of cloud computing technology.

Adapted from Benlian and Hess (2011)

- Hypothesis 1     Logistics/IT managers’ perceived disadvantages of cloud computing adoption are negatively related to their intention to increase the level of cloud computing adoption
- Hypothesis 2     Logistics/IT managers’ perceived advantages of cloud computing adoption are positively related to their intention to increase the level of cloud computing adoption.

### Advantages of Cloud Computing

Cloud computing offers consumers an easy answer for short-term/high-performance needs, temporary solutions (Koomneef, 2011), and reduces or eliminates the costs of acquiring “in-house” services (Buyya, Yeo, Venugopal, Broberg and Brandic, 2009). Benlian and Hess’ (2011) study identified five main advantages of SaaS usage including: cost savings, strategic flexibility, core competencies, specialized resources and quality improvement. Cost advantages relate to the added functionality at a lower cost due to economies of scale, maintenance savings, and ownership development, among others. Strategic flexibility refers to the flexibility that cloud computing provides (e.g., on-demand application delivery, vendor lock-in) compared to traditional in-house software. A focus on core business will allow management to place their attention on areas that create value, without the concern of day-to-day IT management. Access to leading-edge IT resources improve the leverage of firms’ skills, resources and capabilities. Quality improvements assess the expected increase in efficiency and effectiveness of the processes that have adopted cloud computing (Benlian and Hess, 2011). The hypothesized relationship of the IT executives’ assessment of the overall opportunities associated with SaaS usage are replicated and extended to PaaS and IaaS usage.

Adapted from Benlian and Hess (2011)

- Hypothesis 3     Logistics/IT managers’ beliefs about cloud computing adoption's cost advantages are positively related to its overall perceived advantages.
- Hypothesis 4     Logistics/IT managers’ beliefs about the strategic flexibility available through cloud computing adoption are positively related to its overall perceived advantages.
- Hypothesis 5     Logistics/IT managers’ beliefs about its focus on core competencies through cloud computing adoption are positively related to its overall perceived advantages.
- Hypothesis 6     Logistics /IT managers’ beliefs about the firm’s access to specialized resources through cloud computing adoption are positively related to its overall perceived advantages.
- Hypothesis 7     Logistics/IT managers’ beliefs about quality improvements through cloud computing adoption are positively related to its overall perceived advantages.

### Disadvantages of Cloud Computing

Some of the concerns of cloud computing are the security of the services and the lack of expertise among IT staff. Cloud services store and/or process sensitive data outside of the firms’ control, which raises concerns over the safety of the data. Additionally, the integration and data processing speed of many independent and/or loosely coupled applications is also challenging. Several services do not support virtualization or require considerable customization. Cloud computing necessitates a high standard of control and accountability of services (Koomneef, 2011, Reuters, 2011).

Benlian and Hess’ (2011) research listed five types of risks related to the use of SaaS, which include: performance, economic, strategic, security and managerial. Performance risks affect the expected level of service due to connectivity problems, interoperability with house applications, or lack of support of daily operations. Economic risks assess whether the level of service anticipated is equivalent to the payments made and identify any hidden costs. Strategic risks affect firms’ critical resources and capabilities when adopting cloud applications. Security risks inquire about data, backup and recovery procedures in place to avoid data losses. Managerial risks evaluate the impact of cloud computing on the personal affairs of managers responsible for the adoption (Benlian and Hess, 2011). Furthermore, Benlian and Hess (2011) defined perceived risks as “the potential for loss in the pursuit of a desired outcome when sourcing software as a service.” In this study, perceived disadvantages of cloud computing are defined as “the potential loss in the pursuit of a desired outcome when sourcing cloud computing services such as SaaS, PaaS and IaaS.” The derived hypotheses of Logistics/IT managers’ perception of the overall disadvantages of cloud computing are listed below:

Adapted from Benlian and Hess (2011)

- Hypothesis 8     Logistics/IT managers’ beliefs about the performance risks of cloud computing adoption are positively related to its overall perceived disadvantages.
- Hypothesis 9     Logistics/IT managers’ beliefs about the economic risks of cloud computing adoption are positively related to its overall perceived disadvantages.
- Hypothesis 10     Logistics/IT managers’ beliefs about the strategic risks of cloud computing adoption are positively related to the overall perceived disadvantages.
- Hypothesis 11     Logistics/IT managers’ beliefs about the security risks of cloud computing adoption are positively related to the overall perceived disadvantages.
- Hypothesis 12     Logistics/IT managers’ beliefs about the managerial risks of cloud computing adoption are positively related to the overall perceived disadvantages.

Numerous logistics systems that have traditionally been available in-house are now available in the cloud – WMS and TMS, and ERP, among others. Modernizing these systems allows firms to expand their capabilities and lower their software expenses. Firms gain access to real-time data and reduce synchronization issues with customers’ or suppliers’ software. The

adoption of cloud computing can also raise concerns related to security, data ownership, vendor lock-in, customization, integration and performance that need to be carefully evaluated before choosing to implement cloud computing (SupplyChainBrain, 2011). The advantages and disadvantages of cloud computing make some logistics systems more suitable for the cloud. As a result, the logistics/IT managers' perceived advantages and disadvantages of cloud computing use will determine the type of systems they perceive are appropriate for the cloud.

Hypothesis 13 Logistics/IT managers' beliefs about advantages and disadvantages of cloud computing adoption are positively related to the overall selection of logistics systems appropriate for the cloud.

Public, private and hybrid clouds are available to overcome cost and security factors. It is hypothesized that companies that are more concerned about cost and less concerned about security will prefer to adopt public clouds; financially stable companies that are more concerned about security will prefer to adopt private clouds; companies' conscious about cost and security will prefer to adopt hybrid clouds.

Hypothesis 14 Logistics/IT managers' strong beliefs of security importance are positively related to the type of cloud computing deployment.

Hypothesis 15 Logistics/IT managers' strong beliefs of cost savings importance are positively related to the type of cloud computing deployment.

Hypothesis 16 Logistics/IT managers' beliefs of both security and cost savings importance are positively related to the type of cloud computing deployment.

## METHODOLOGY

Survey methodology will be used to test the hypothesis regarding cloud computing adoption among logistics companies, following the total design method (Dillman, 2000). Additionally, structural equation modeling will be used for the analysis. The survey items were adapted from a scale previously used in the literature (Benlian and Hess, 2011). Pre-testing has been completed in that the survey has been reviewed by academic experts, Ph.D. Logistics students and experienced managers, for clarity, readability, specificity, representativeness, content validity and face validity. The survey's target group has been identified and data collection will begin this year.

## CONCLUSIONS, MANAGERIAL IMPLICATIONS AND LIMITATIONS

The empirical results of this study aim to contribute to the understanding of the perceived decision factors of cloud computing adoption among the logistics industry. The integration of cloud applications and processes enable faster and more effective cross-enterprise and extended supply chain analysis and reporting (Schramm, Wright, Seng and Jones, 2010). Shifting away from traditional in-house or outsource contracted models to more flexible, transaction-based models requires supply chain decision makers to evaluate what cloud computing means for their operations and not leaving the decision to the IT department (McAfee, 2011, Schramm, et al., 2010). The relative importance of advantages and disadvantages of cloud computing will be established by focusing on specific logistics information systems, and factors influencing the types of cloud deployment and cloud service are expected to be identified.

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